

Reclaimed, Surface and Groundwater Quality What's the Difference?

A Report on WaterReuse Foundation
Project WRF-02-008



The Future of Water Reuse in the State of Maryland
MDE/UMBC/CWEA/CS:AWWA
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WateReuse Foundation

Project Teams

- Presenters and Principal Investigators
 - Thomas J. Helgeson, P.E., CH2M HILL
 - Mark B. McNeal, P.G., ASRus, LLC
 - Theresa R. Slifko, Ph.D., Orange County Utilities
- Co-Authors/Project Team
 - Jeff Nash and Cory Johnson, CH2M HILL, Orlando, FL
 - Diane Vaughn and Kimberly Kunihiro, Orange County Utilities
 - Darlene Crosby, City of Orlando
 - Jose Polar, Samer Abdul Aziz and James Englehardt, Ph.D., University of Miami
 - Michael Meyer, Ph.D., United States Geological Survey
 - Piero Gardinali, Ph.D., Florida International University

WateReuse Foundation Project Teams

- Project Advisory Committee
 - Anthony Andrade, Southwest Florida Water Management District (SWFWMD)
 - Jean Debroux, Kennedy Jenks Consultants
 - Bob Jurenka, United States Bureau of Reclamation
 - Christine Owen, Tampa Bay Water

Today's Agenda

- Background/Overview
- Expectations
- Results

Today's Agenda

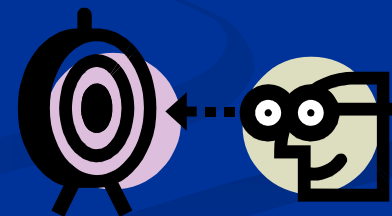
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Project Drivers

- Impacts of development and population growth
- Increasing rate of reuse
- “Interconnectedness” of karstic geology and water matrices
- Uncertainty with respect to microconstituents

Project Objective

...to investigate and document the water quality of reclaimed water as well as surface waters and groundwaters influenced, and not influenced, by municipal wastewater discharges and/or reclaimed water



Water Matrices Selected for Study

- Surface and ground waters that have minimal or no direct influence from treated municipal wastewater and/or reclaimed water discharges
- Surface and ground waters that are known to be influenced by treated municipal wastewater and/or reclaimed water discharges
- Reclaimed Water

Project Workflow

- Conduct Literature Survey
- Develop Constituent List
- Develop Sampling Plan
- Select participating utilities
 - 10 in Florida
 - 1 in California
- Collect and analyze samples (wet and dry seasons)
 - Surface water
 - Ground water
 - Reclaimed water
- Analyze and summarize data
- Prepare Research Report



Constituents:

Many Analytes were Considered!

- Primary and Secondary Inorganic Drinking Water Standards
- Volatile Organics
- Synthetic Organic Contaminants
- TOC
- TOX



- Microbiologicals
 - Total Coliforms
 - Non-Coliforms
 - Fecal Streptococci
 - Enterococci
 - Coliphages
 - Enterovirus
 - *Cryptosporidium*
 - *Giardia*
 - Helminth ova
- Organic Wastewater Contaminants
- Microconstituents (>100 analytes)
 - Pharmaceuticals
 - Antibiotics
 - Endocrine disruptors

Constituents: Groundwater Categories/Parameters

Evaluation Category	Parameters Evaluated
Nutrients	Nitrate + Nitrite-Nitrogen, and Total Phosphorus
Biologicals	Total Coliform and Fecal Coliform
Metals	Primary Metals (Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Lead, Mercury, Nickel, Selenium, and Thallium) Selected Secondary Metals (Aluminum, Copper, Iron, Manganese, Silver, Strontium, Vanadium, and Zinc)
Organics	Volatile and Semivolatile Organics, and Pesticides
Saline Waters	Sodium, Chloride, Sulfate, Total Dissolved Solids, and Specific Conductance
Ground Water– Surface Water Interaction	Total Dissolved Solids, Total Organic Carbon, Specific Conductance, Dissolved Oxygen, and others as appropriate

Constituents:

Florida Reuse Water Guidelines

Reclaimed Water Quality and Treatment Requirements (Unrestricted Public Access)

- Secondary treatment with filtration and high-level disinfection
- Chemical feed facilities to be provided
- 20 mg/l CBOD5 (annual average)
- 5 mg/l TSS (single sample) to be achieved prior to disinfection
- Total chlorine residual of at least 1 mg/l after a minimum acceptable contact time of 15 minutes at peak hourly flow
- Fecal coliform
 - over 30 day period, 75 % of samples below detection limits
 - ≤ 25 CFU/100 ml (single sample)
- pH 6 - 8.5

Constituents:

Class III Surface Water Guidelines

- Chapter 62-302.530
- Defined by 70 constituents
- Organic compounds at concentrations of $\mu\text{g/L}$



Biological Microconstituents

- Contaminant Candidate List (CCL) Organisms

- *Acanthamoeba*
- Adenoviruses
- *Aeromonas hydrophila*
- Caliciviruses
- Coxsackieviruses
- Cyanobacteria
- Echoviruses
- *Helicobacter pylori*
- Microsporidia
- *Mycobacterium avium intracellulare* (MAC)

- Alternative indicator organisms

- Prions
- Nanobacteria
- Others



Constituent Selection

- Selection was focused on constituents with robust analytical methods
- Extensive literature survey summarized all published data and methods available at that time
- Potential constituents exceeded 1,000
- Analytical efficiency at Orange County's laboratory enabled a broader scope than the initial budget indicated
- Other, complementary analytical protocols enabled additional work – better bang for the lab buck

At the End of the Day...

Key Microconstituents Selected

Parameter Group*	No. Constituents in Analytical Suite	Examples of Selected Microconstituents	Analytical Method for Selected Examples)
Organics & Volatile Organic Compounds (VOCs, THMs, & HAAs)	109	NDMA DEET Dichloroacetic acid MTBE	Nitrosamine Suite FIU Pharma Screen EPA 552.2 EPA 8260
Metals*	27	Arsenic Chloride	SM 3113B EPA 200.7
Nutrients*	8	TKN TP OP	EPA 351.2 EPA 365.4, 365.1 EPA 365.1
Wet Chemistry	7	TSS	EPA 160.2
Field Parameters	8	Turbidity Specific Conductance	EPA 150.1 EPA 120.1
Microbiologicals	11	<i>Cryptosporidium</i> <i>Giardia</i> Enteric viruses	EPA 1623 ASTM D4994-89 (modified)
Pharmaceuticals, Steroids, and Hormones	20	Caffeine 17b-estradiol	FIU Pharma Screen Steroid-hormone Screen
Antibiotics	15	Erythromycin	USGS Antibiotic Suite
Pesticides/Herbicides	19	Atrazine	FIU Triazine Suite
TOTAL	244		

Sampling Site Selection Process

- Selection considered:
 - Sites impacted and not impacted by reclaimed water
 - Determination of pristine sites
 - Avoidance of private septic system interference
 - Avoidance of reclaimed water compliance wells
 - Sufficient sample size draw statistically significant results
- Project Advisory Committee/Participating Utilities/Project Team – background knowledge aided detailed site evaluation
- Uniformity of treatment process critical to comparability
- Difficulty with western sites
 - treatment
 - anonymity
 - fear of the unknown

Sampling Plan

- Wet Season

- 40 samples
- 5 QA/QC

- Dry Season

- 40 samples
- 5 QA/QC

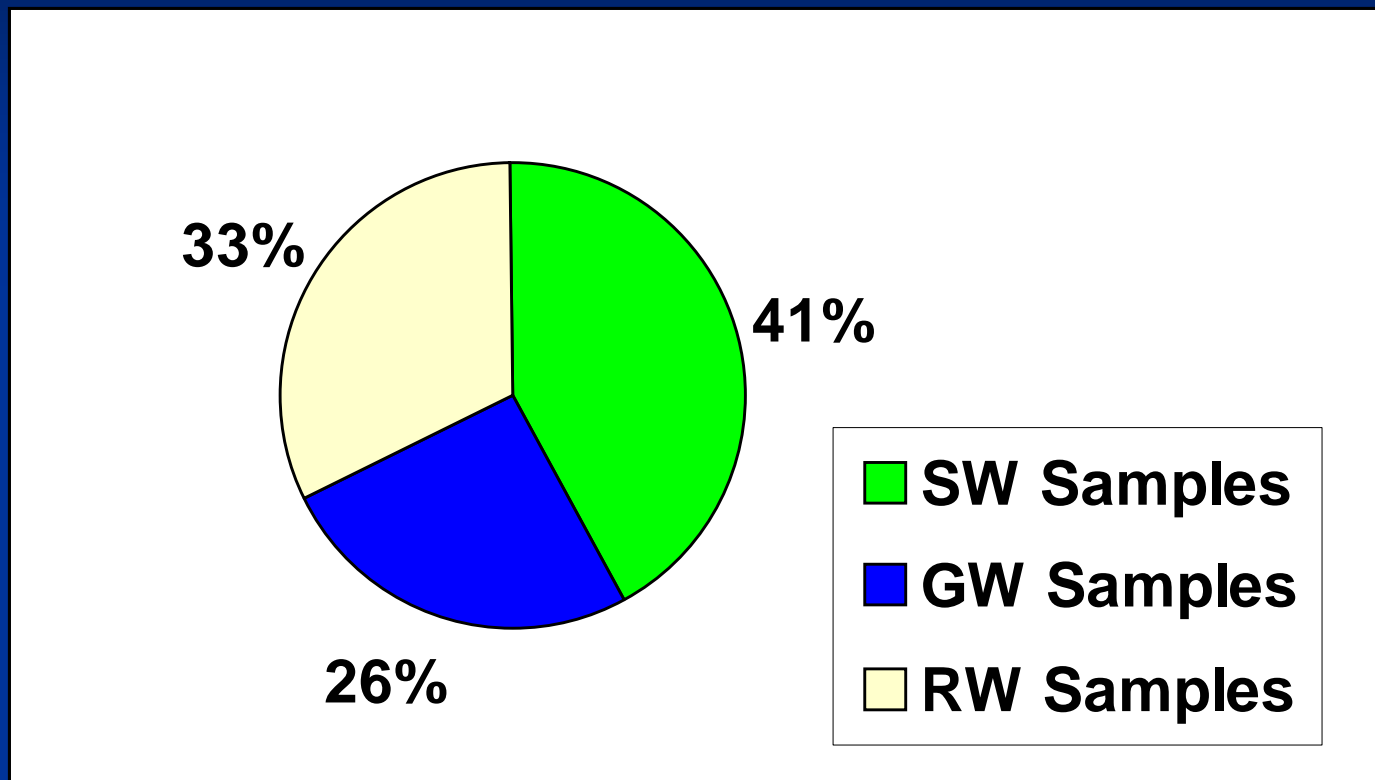
Total: 90 Sets of Samples & >20,000 pieces of data

Sampling Plan Challenges

- Multiple participating utilities
 - Confidentiality extremely important to some
- Different sampling teams for each utility and sometimes within the utility (different divisions)
- Three distinct water matrices
 - Surface water sampled by boat
 - Groundwater requires sampling pumps
- Field sample collection SOPs
- Special field collection instructions for personal care products
 - No deodorant!
 - No cosmetics!
 - No insecticide!
 - No coffee?
- Holding times/shipping constraints
- Sample kits



Sample Collection Sites by Water Matrix



Surface water quality believed to be more variable, therefore more sites

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What was Expected?

- Finding differences between groundwater, surface water and reclaimed water
- Determining the existence of a “signature”
- Determine reclaimed water/domestic wastewater impacts to surface and groundwater
- Comprehensive understanding of what could be detected using the most robust methods available

Questions Pondered

- What is the difference between surface waters and groundwaters that have or have not been affected by reclaimed water? What does it mean?
- What is the survival and fate of microorganisms (particularly *Giardia*) from a reclamation facility?
- Can intrusions of treated or untreated waters be traced by their chemical and microbiological signatures?
- Are non-regulated microconstituents present in the reclaimed water and at what concentrations?
- What is the quality of receiving waters with respect to microconstituents?

Questions Pondered

- What are the mass loading magnitudes of microbiological and chemical health stressors in surface/groundwaters as a result of reuse, as a basis for ecological/health risk analysis?
- What changes are observed in groundwater affected by reclaimed water relative to the source? Are changes occurring w/ the microbiology, nutrients, or DBPs?
- What concerns should utilities have when utilizing surface/groundwater under the influence of reclaimed water for potable or non-potable applications?
- Should we be concerned if land application and RIBs are recharging our aquifers, both to public and private users?
- What is the potential harm of drainage wells from which surface water is discharged directly to groundwater? Would introducing reclaimed water affect the risk to the aquifer?

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Analysis

- Data evaluation is underway
- We feel sample sizes were sufficient to draw statistically significant conclusions
- Probability distribution will be developed for the differences in the water matrices using a predictive Bayesian framework
 - Purpose is to mitigate limitations imposed by research budget

What was Not Found?

- 101 of 244 (41%) compounds not found in any samples
 - Androsterone
 - Testosterone
 - α -Estradiol
 - Benzene
 - Toluene
 - Xylene
 - Silver
- 28 additional not found in wet samples
- 13 additional not found in dry samples

Ubiquitous Compounds (All Matrices)

■ Pharmaceuticals

- DEET
- Caffeine
- Triclosan
- Bisphenol-a

■ Hormones/Steroids

- Cholesterol
- Coprostanol

■ Nutrients

- N & P

■ Volatile Organics

- Chloroform

■ Semi-Volatile Organics

- Dichloroacetic acid
- THAs
- Dibromoacetic acid
- Trichloroacetic acid

■ Microbiologicals

- Coliphage, general
- Fecal coliform

■ Synthetic Organics

- Atrazine
- Diethylatrazine (DEA)

Ubiquitous Compounds (SW & RW)

■ Hormones/Steroids

- Estrone
- Coprostanone
- b-Estradiol

■ Volatile Organics

- Bromodichloromethane
- MTBE

■ Semi-Volatile Organics

- Chlorodibromoacetic acid

■ Microbiologicals

- Clostridium perfringens
- Cryptosporidium
- Enterococci
- Giardia

Preliminary Analytical Results

Not available for Publication at this time

Slide Discussion Only



Questions?

Contact:

Thomas J. Helgeson, P.E.

CH2M HILL

813.874.0777

Tom.Helgeson@CH2M.com

Mark McNeal, P.G.

ASRus, LLC

813.264.9100

mmcneal@asrus.net

Theresa R. Slifko, Ph. D.

Orange County Utilities

407.254.9551

Terri.Slifko@OCFL.net